Open-Source Implementation of the DDA for light scattering in an Absorbing Medium

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Background

The theory of light scattering by single particles is well-developed, providing several computational methods which allow one to simulate the process with the desired accuracy. However, most publicly available codes for such computations are limited to non-absorbing host medium, the only exception being the Lorenz-Mie theory [1,2]. On the other hand, the case of absorbing medium is relevant for many practical applications, e.g., for particles submerged in water and droplets in oil.

Results

Technically, the extension of computational methods to the case of absorbing host medium implies the support of complex wavenumber $k = k' + \mathrm{i}k''$. We have implemented this support in the open-source popular discrete-dipole approximation code ADDA [3]. However, a more challenging task is to define scattering quantities such as the extinction, scattering and absorption cross-sections, preserving the physical sense at least for weakly absorbing medium. Here the physical sense means certain decoupling of particle's properties from far-field detector geometry (taken for granted for non-absorbing host medium), i.e. those two can be changed independently and later combined to calculate the detector response. One option is to use definitions based on far-field limit, but without the common attenuation factor $\exp(-2k''r)$. Such definitions are realized in the existing codes for spherical particles and can be computed by ADDA as well, resulting in perfect agreement. Moreover, the required far-field integration can be reduced to that over the particle's volume, which is faster and more natural for the DDA method. We will also discuss a meaningful definition of the extinction cross section in weakly absorbing medium, which can be used to predict the extinction by a diluted slab of particles.

References

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